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TITLE: MICROWAVE PLASMA TREATMENT DEVICE

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ABSTRACT:

PURPOSE: To enable a plasma treatment device to uniformly treat the surface of a board by a method wherein a gas discharge structure having a two-dimensional array of a large number of holes for emitting neutral gas is provided at a boundary between a plane antenna and a plasma generating region,

where the plasma treatment device generates plasma taking advantage of an
electron cyclotron resonant effect.

CONSTITUTION: A treating region where plasma 6 is generated and an antenna
region are isolated from each other by a dielectric plate 3 and a dielectric
gas discharge plate 7. Gas required for treatment is fed to a vacuum chamber 2
through a gas inlet 5 from outside. Gas fed to the vacuum chamber 2 is
discharged out into a plasma generating region through a large number of holes
which are below several millimeters in diameter and bored in the dielectric gas
discharge plate 7. Plasma 6 of high density is generated by an electromagnetic
cyclotron resonance induced between a magnetic coil 4 and microwaves radiated
from a plane antenna 1. In this case, gas required for treatment is discharged
out toward plasma 6 through a large number of holes provided to the dielectric
gas discharge plate 7. Therefore, plasma can be kept spatially uniform in
density.

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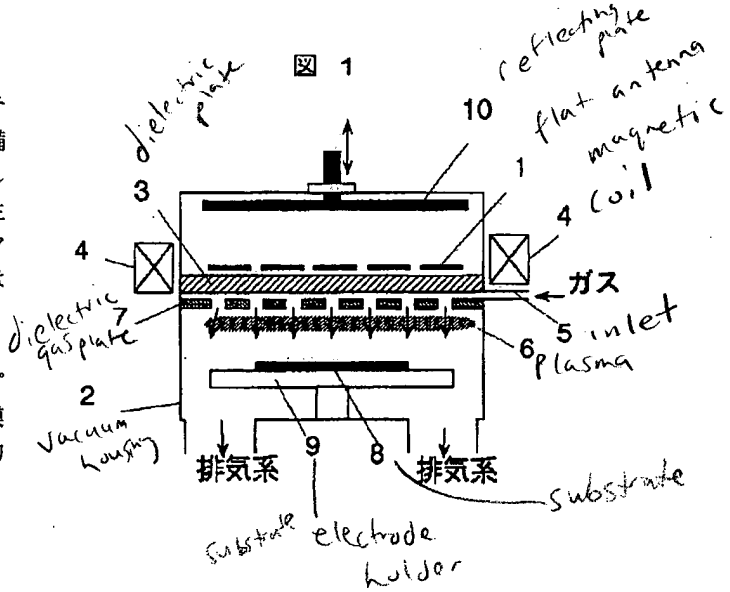
(54)【発明の名称】　マイクロ波プラズマ処理装置

(57)【要約】

【構成】マイクロ波をプラズマへ放射する平面状アンテナ１と磁場を発生させる電磁石または永久磁石１１を備え、電子サイクロトロンの効果を利用して電子を加速して中性ガスを衝突電離することによりプラズマ６を発生させるプラズマ処理装置は、平面アンテナ１とプラズマ発生領域との境界にマイクロ波が透過可能な材質または構造により中性ガスを放出する孔を面状に多数配置する。

【効果】処理に必要なガスが基板上に均一に放射されプラズマが効率良く一様に発生できるので、基板への成膜やエッチング等の処理が均一に高効率で行えるという効果がある。

図１



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【特許請求の範囲】

【請求項1】マイクロ波をプラズマへ放射する平面アンテナと磁場を発生させる電磁石または永久磁石とを備え、電子サイクロトロンの効果を利用して電子を加速して中性ガスを衝突電離することによりプラズマを発生させるプラズマ処理装置において、前記平面アンテナとプラズマ発生領域との間に前記マイクロ波が透過可能で前記中性ガスを放出する多数の孔を面状に配置したガス放出機構を設けたことを特徴とするマイクロ波プラズマ処理装置。

【請求項2】請求項1において、前記ガス放出機構は、2枚の誘電体板を数㎜以下の間隔で取付けて、前記誘電体板のうち前記プラズマ発生領域側に直径数㎜以下の孔を多数開けたことを特徴とするマイクロ波プラズマ処理装置。

【請求項3】請求項1において、前記平面アンテナの前記プラズマ発生領域と反対側にマイクロ波反射板を設け、前記マイクロ波反射板と前記平面アンテナとの距離を可変としたマイクロ波プラズマ処理装置。

【請求項4】請求項1において、前記磁場発生手段として電磁石と永久磁石を併用するマイクロ波プラズマ処理装置。

【請求項5】請求項1において、前記平面アンテナの構造が櫛の歯状で前記櫛の歯の間隔が前記マイクロ波の半波長程度で、前記歯の長さが半波長の整数倍程度であるマイクロ波プラズマ処理装置。

【請求項6】請求項1において、前記平面アンテナの構造が放射状に二つ以上の電極が並び該電極の長さが前記マイクロ波の半波長の整数倍程度であるマイクロ波プラズマ処理装置。

【発明の詳細な説明】

【0001】

【産業上の利用分野】本発明は、マイクロ波と磁場の相互作用を利用してプラズマを発生させ、プラズマにより基板のエッチングや薄膜形成等の表面処理を行うマイクロ波プラズマ処理装置に関する。

【0002】

【従来の技術】従来のマイクロプラズマ処理装置は、特開平2−156526 号公報に記載のように、原料ガスの供給方法については特に考慮されておらず、アンテナは単に直線状電極を用いている。

【0003】

【発明が解決しようとする課題】従来の装置によれば、原料ガスの供給がプラズマ発生領域の周辺にあるため、高密度プラズマを発生させて処理の高速化を行う場合に、基板中央部の原料ガスが供給不足になりプラズマ密度が周辺で高く中央で低い分布になり基板上の処理が不均一になる。また、アンテナ構造が単に直線状電極であるためにマイクロ波の放射効率が低く、マイクロ波の利用効率が必ずしも良くなかった。

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【0004】本発明の目的は、前述の課題を解決したマイクロ波プラズマ処理装置を提供することにある。

【0005】

【課題を解決するための手段】前記目的を達成するために、本発明はマイクロ波をプラズマへ放射する平面状アンテナと磁場を発生させる電磁石または永久磁石を備え、電子サイクロトロン共鳴の効果を利用して電子を加速して中性ガスを衝突電離することによりプラズマを発生させるプラズマ処理装置において、平面アンテナとプラズマ発生領域との境界に中性ガスを放出する孔を面状に多数配置したガス放出構造を設け、平面アンテナの後方に反射板を設け、アンテナの特徴的寸法をマイクロ波の半波長の整数倍とした。

【0006】

【作用】処理の高速化のためには高密度プラズマを発生させることが重要であるが、従来のように処理に必要なガスをプラズマ発生領域の周辺から供給するとプラズマ密度分布が不均一になる。本発明の方法では、ガスを基板上で面状に放出するためガスの分布及びプラズマ密度分布が一様になり、処理の均一性が向上する。また、平面アンテナの電極長をマイクロ波の半波長の整数倍にすることにより、マイクロ波が電極部に共振しマイクロ波放射効率が良くなる。また、平面アンテナの後方に反射板を設け、アンテナと反射板との距離を調整することでアンテナから後方に放射されたマイクロ波を効率良くプラズマ側に反射できマイクロ波の利用効率が改善される。

【0007】

【実施例】以下、本発明の一実施例を図1に従って説明する。本実施例の装置は真空容器2と磁場を発生させるための磁場コイル4とからなり、真空容器2の内部には基板ホルダ9で保持された基板8のある処理領域と平面アンテナ1と反射板10のあるアンテナ領域からなる。プラズマ6を発生させる処理領域とアンテナ領域とは、誘電体板3と誘電体ガス放出板7で分離されている。誘電体板3と誘電体ガス放出板7とは間隔が数㎜以下の隙間を持って真空容器2に気密に固定されており、隙間には真空容器2外部よりガス導入口5を通じて処理に必要なガスが供給され、供給されたガスは誘電体ガス放出板7に多数開けられた直径数㎜以下の孔を通してプラズマ発生領域に放出される。プラズマの発生は磁場コイル4と平面アンテナ1から放射されるマイクロ波との電子サイクロトロン共鳴の効果により、共鳴を起こす磁場強度875ガウス（マイクロ波周波数が4.45GHz の場合）の位置で効果的にガスが電離され高密度のプラズマ6が生成される。この場合、処理に必要なガスが誘電体ガス放出板7の多数の孔を通してプラズマ6に供給されるので、プラズマ密度が空間的に一様であり均一な処理が可能になる。また、反射板10を上下方向に操作して平面アンテナ1との距離を調節することで、プラズマ6

方向へのマイクロ波の強度を増加させることができるため、ガスの電離が活発になりプラズマの生成効率が改善される。平面アンテナ１の構造は、例えば、図４及び図５のようにアンテナの電極の長さをマイクロ波波長λに対して（ｎ＋１／２）λ倍（ｎ：整数）にすることで、マイクロ波が共鳴的に電極部に定在波が形成され放射効率が向上する。また、大面積基板を処理する場合は図６の実施例のように、本実施例の装置を直線状または平面上に複数個連結させることで、処理すべき基板の大きさに合わせてプラズマの大きさを変えられる。

【０００８】次に本発明の第２の実施例を図２により説明する。本実施例は、第１の実施例の磁場発生手段である磁場コイル４に加えて永久磁石１１を併用したものである。永久磁石１１は平面アンテナ１近くに取付けプラズマ６の発生領域に数百ガウスの磁場を発生し、近接する磁石の極性Ｎ，Ｓを逆にすることで局所的にカスプ磁場を形成する。本実施例では、電子サイクロトロン共鳴に必要な磁場強度を磁場コイル４と永久磁石１１を併用して発生させるため、磁場コイル４に給電される電力を低くできる。

【０００９】次に本発明の第３の実施例を図３により説明する。本実施例は、第１の実施例の磁場発生手段である磁場コイル４の代わりに永久磁石１１を用いたものである。永久磁石１１は平面アンテナ１近くに取付けプラズマ６の発生領域に数百ガウスの磁場を発生し、近接する磁石の極性Ｎ，Ｓを逆にすることで局所的にカスプ磁場を形成する。本実施例では、永久磁石１１のみで磁場を発生させるため、装置寸法が小型化され経済的である。

【００１０】次に本発明の第４の実施例を図７により説明する。本実施例は、第１の実施例の平面アンテナ１の取付け位置を誘電体板３と誘電体ガス放出板７との間に変えたものである。本実施例では、中性ガスの流路内に平面アンテナ１があるためガスの流れを多少妨げるが、平面アンテナ１をプラズマ６の発生領域近くに平面アンテナ１があるためマイクロ波のプラズマ６への吸収効率が良くなる。

【００１１】

【発明の効果】本発明によれば、処理に必要なガスが基板上に均一に放射されプラズマを効率良く一様に発生できるので、基板への成膜やエッチング等の処理が均一に高効率で行えるという効果がある。さらに、大面積基板を処理する場合においても、本発明の装置を複数個連結することにより任意の面積でプラズマを発生させ処理を行える。

【図面の簡単な説明】

【図１】本発明の第１の実施例を示す説明図。

【図２】本発明の第２の実施例を示す説明図。

【図３】本発明の第３の実施例を示す説明図。

【図４】本発明の平面アンテナ構造例を示す説明図。

【図５】本発明の平面アンテナ構造例を示す説明図。

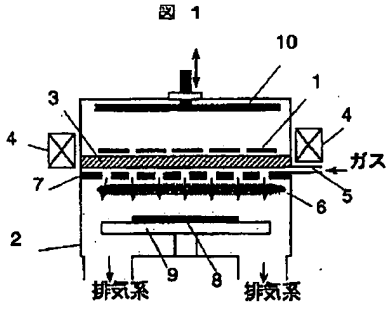
【図６】本発明の装置の連結方法を示す説明図。

【図７】本発明の第４の実施例を示す説明図。

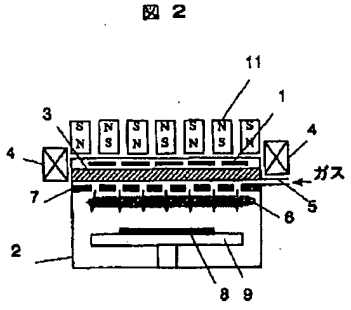
【符号の説明】

１…平面アンテナ、２…真空容器、３…誘電体板、４…磁場コイル、５…ガス導入口、６…プラズマ、７…誘電体ガス放出板、８…基板、９…基板ホルダ、１０…反射板、１１…永久磁石。

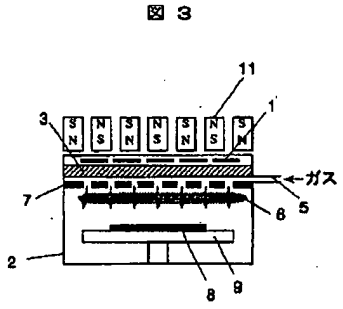
【図１】



【図２】

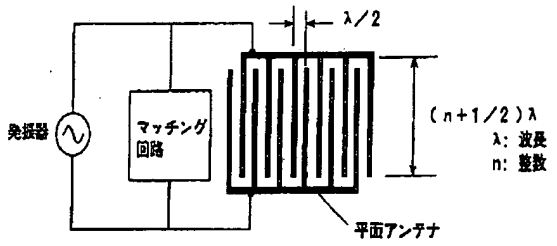


【図３】



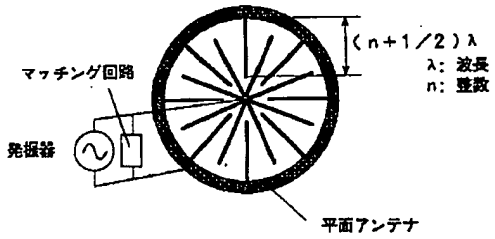
【図4】

図 4



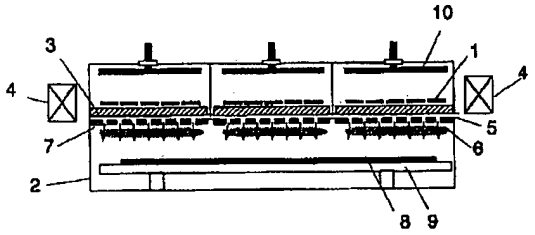
【図5】

図 5



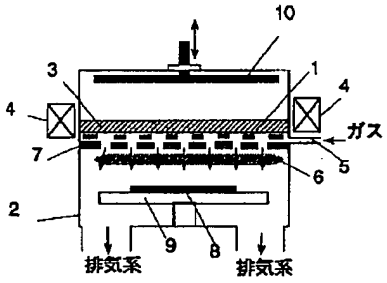
【図6】

図 6



【図7】

図 7



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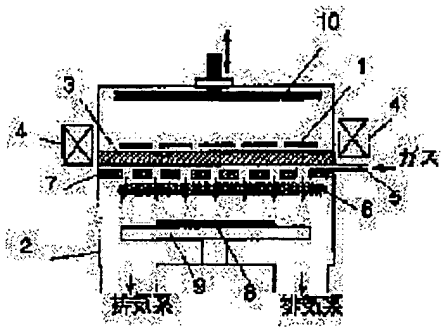
(54) MICROWAVE PLASMA TREATMENT DEVICE

(57)Abstract:

PURPOSE: To enable a plasma treatment device to uniformly treat the surface of a board by a method wherein a gas discharge structure having a two-dimensional array of a large number of holes for emitting neutral gas is provided at a boundary between a plane antenna and a plasma generating region, where the plasma treatment device generates plasma taking advantage of an electron cyclotron resonant effect.

CONSTITUTION: A treating region where plasma 6 is generated and an antenna region are isolated from each other by a dielectric plate 3 and a dielectric gas discharge plate 7. Gas required for treatment is fed to a vacuum chamber 2 through a gas inlet 5 from outside. Gas fed to the vacuum chamber 2 is discharged out into a plasma generating region through a large number of holes which are below several millimeters in diameter and bored in the dielectric gas discharge plate 7. Plasma 6 of high



density is generated by an electromagnetic cyclotron resonance induced between a magnetic coil 4 and microwaves radiated from a plane antenna 1. In this case, gas required for treatment is discharged out toward plasma 6 through a large number of holes provided to the dielectric gas discharge plate 7. Therefore, plasma can be kept spatially uniform in density.

LEGAL STATUS

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[Date of sending the examiner's decision of rejection]	
[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]	
[Date of final disposal for application]	
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[Date of registration]	24.11.2000
[Number of appeal against examiner's decision of rejection]	
[Date of requesting appeal against examiner's decision of rejection]	
[Date of extinction of right]	

* NOTICES *

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] Explanatory drawing showing the 1st example of this invention.
[Drawing 2] Explanatory drawing showing the 2nd example of this invention.
[Drawing 3] Explanatory drawing showing the 3rd example of this invention.
[Drawing 4] Explanatory drawing showing the example of flat antenna structure of this invention.
[Drawing 5] Explanatory drawing showing the example of flat antenna structure of this invention.
[Drawing 6] Explanatory drawing showing the connection method of the equipment of this invention.
[Drawing 7] Explanatory drawing showing the 4th example of this invention.
[Description of Notations]
1 [-- A dielectric board, 4 / -- A magnetic field coil, 5 / -- A gas inlet, 6 / -- Plasma, 7 / -- A dielectric gas-evolution board, 8 / -- A substrate, 9 / -- A substrate electrode holder, 10 / -- A reflecting plate, 11 / -- Permanent magnet.] -- A flat antenna, 2 -- A vacuum housing, 3

[Translation done.]

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CLAIMS

[Claim(s)]
[Claim 1] the microwave plasma-treatment equipment characterized by to establish the gas-evolution mechanism which has arranged the hole which are a large number which can penetrate the aforementioned microwave between the aforementioned flat antenna and a plasma generating field, and emit the aforementioned inert gas to it in the plasma-treatment equipment which makes generate plasma by having the electromagnet or the permanent magnet which makes generate the flat antenna which emits microwave to plasma, and a magnetic field, accelerating an electron using the effect of an electronic cyclotron, and carrying out the ionization by collision of the inert gas in the shape of a field
[Claim 2] It is microwave plasma treatment equipment characterized by for the aforementioned gas-evolution mechanism having attached two dielectric boards at intervals of several mm or less in the claim 1, and opening many holes with a diameter of several mm or less in the aforementioned plasma generating field side among the aforementioned dielectric boards.
[Claim 3] Microwave plasma treatment equipment which prepared the microwave reflecting plate in the aforementioned plasma generating field and opposite side of the aforementioned flat antenna, and made adjustable distance of the aforementioned microwave reflecting plate and the aforementioned flat antenna in the claim 1.
[Claim 4] Microwave plasma treatment equipment which uses an electromagnet and a permanent magnet together as the aforementioned magnetic field generating means in a claim 1.
[Claim 5] Microwave plasma treatment equipment whose length of the aforementioned gear tooth the interval of the gear tooth of the aforementioned comb is the integral multiple grade of the half-wave length in the half-wave length grade of the aforementioned microwave in a claim 1 at the toothed of a comb for the structure of the aforementioned flat antenna.
[Claim 6] Microwave plasma treatment equipment whose length of this electrode two or more electrodes is the integral multiple grades of the half-wave length of the aforementioned microwave together with a radial in a claim 1 for the structure of the aforementioned flat antenna.

[Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] this invention generates plasma using the interaction of microwave and a magnetic field, and relates to the microwave plasma treatment equipment which performs surface treatment, such as etching of a substrate, and thin film formation, by plasma.
[0002]
[Description of the Prior Art] The conventional microplasma processor is not taken into consideration especially about the supply method of material gas like the publication to JP,2-156526,A, but the antenna only uses the straight-line-like electrode.
[0003]
[Problem(s) to be Solved by the Invention] Since supply of material gas is around a plasma generating field, when according to conventional equipment generating high-density plasma and accelerating processing, the material gas of a substrate center section becomes short supply, plasma density becomes a low distribution in the center highly on the outskirts, and the processing on a substrate becomes uneven. Moreover, since antenna structure was only a straight-line-like electrode, the radiant efficiency of microwave was low, and the use efficiency of microwave was not necessarily good.
[0004] The purpose of this invention is to offer the microwave plasma treatment equipment which solved the above-mentioned technical problem.
[0005]
[Means for Solving the Problem] this invention is equipped with the electromagnet or permanent magnet made to generate the plane antenna which emits microwave to plasma, and a magnetic field in order to attain the aforementioned purpose. In the plasma treatment equipment made to generate plasma by accelerating an electron using the effect of a electron cyclotron resonance, and carrying out the ionization by collision of the inert gas The gas-evolution structure which has arranged many holes which emit an inert gas to the boundary of a flat antenna and a plasma generating field in the shape of a field was established, the reflecting plate was prepared behind the flat antenna, and the characteristic size of an antenna was made into the integral multiple of the half-wave length of microwave.
[0006]
[Function] Although it is important for improvement in the speed of processing to generate high-density plasma, if gas required for processing is supplied from the circumference of a plasma generating field like before, plasma density distribution will become uneven. By the method of this invention, in order to emit gas in the shape of a field on a substrate, a distribution and plasma density distribution of gas become uniform, and the homogeneity of processing improves. Moreover, by making the electrode length of a flat antenna into the integral multiple of the half-wave length of microwave, microwave resonates to the polar zone and microwave radiation efficiency becomes good. Moreover, a reflecting plate is prepared behind a flat antenna, the microwave emitted to back from the antenna can be efficiently reflected in a plasma side by adjusting the distance of an antenna and a reflecting plate, and the use efficiency of microwave is improved.

[0007]
[Example] Hereafter, one example of this invention is explained according to drawing 1 . The equipment of this example consists of a magnetic field coil 4 for generating a vacuum housing 2 and a magnetic field, and consists of an antenna field with the processing field and flat antenna 1 which have the substrate 8 held with the substrate electrode holder 9 in the interior of a vacuum housing 2, and a reflecting plate 10. The processing field and antenna field which generate plasma 6 are separated by the dielectric board 3 and the dielectric gas-evolution board 7. The gas by which the interval was being airtightly fixed to the vacuum housing 2 with the crevice several mm or less, gas required for processing was supplied and the dielectric board 3 and the dielectric gas-evolution board 7 were supplied to the crevice through the gas inlet 5 from the vacuum housing 2 exterior is emitted to the dielectric gas-evolution board 7 to a plasma generating field through the hole with a diameter of several mm or less which were able to be opened. Gas is ionized effectively (when microwave frequency is 4.45GHz) by generating of plasma in the position of 875 gausses of magnetic field intensity which causes resonance by the effect of the electron cyclotron resonance of the magnetic field coil 4 and the microwave emitted from a flat antenna 1, and the high-density plasma 6 is generated. In this case, since gas required for processing is supplied to plasma 6 through many holes of the dielectric gas-evolution board 7, uniform and uniform processing is spatially attained by plasma density. Moreover, by operating a reflecting plate 10 in the vertical direction, and adjusting distance with a flat antenna 1, since the intensity of the microwave to plasma 6 direction can be made to increase, ionization of gas becomes active and the generation efficiency of plasma is improved. the structure of a flat antenna 1 is lambda (n+1/2) doubling the length of the electrode of an antenna to the microwave wavelength lambda like drawing 4 and drawing 5 (n : integer), a standing wave is formed in the polar zone in [microwave] resonance, and its radiant efficiency improves Moreover, when processing a large area substrate, like the example of drawing 6 , it is making two or more equipments of this example connect on the shape of a straight line, and a flat surface, and the size of plasma can be changed according to the size of the substrate which should be processed.
[0008] Next, drawing 2 explains the 2nd example of this invention. In addition to the magnetic field coil 4 which is the magnetic field generating means of the 1st example, this example uses a permanent magnet 11 together. A permanent magnet 11 is attached in about one flat antenna, and a cusp field is locally formed in the generating field of plasma 6 by generating a hundreds of gausses magnetic field and making the polarity N of the approaching magnet, and S reverse. In this example, since the magnetic field coil 4 and a permanent magnet 11 are used together and magnetic field intensity required for a electron cyclotron resonance is generated, power to which electric power is supplied by the magnetic field coil 4 can be made low.
[0009] Next, drawing 3 explains the 3rd example of this invention. A permanent magnet 11 is used for this example instead of the magnetic field coil 4 which is the magnetic field generating means of the 1st example. A permanent magnet 11 is attached in about one flat antenna, and a cusp field is locally formed in the generating field of plasma 6 by generating a hundreds of gausses magnetic field and making the polarity N of the approaching magnet, and S reverse. In this example, in order to generate a magnetic field only with a permanent magnet 11, an equipment size is miniaturized and it is economical.
[0010] Next, drawing 7 explains the 4th example of this invention. this example changes the fitting location of the flat antenna 1 of the 1st example between the dielectric board 3 and the dielectric gas-evolution board 7. Although some flows of gas are barred in this example since a flat antenna 1 is in the passage of an inert gas, since a flat antenna 1 is near the generating field of plasma 6 about a flat antenna 1, the absorption efficiency to the plasma 6 of microwave becomes good.
[0011]
[Effect of the Invention] Since according to this invention gas required for processing is uniformly emitted on a substrate and can generate plasma uniformly efficiently, it is effective in it being uniformly efficient and being able to perform processing of the membrane formation to a substrate, etching, etc. Furthermore, when processing a large area substrate, it can process by generating plasma in an arbitrary area by connecting two or more equipments of this invention.

h g cg b eb cg e e

[Translation done.]

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